Simulations of the tropical circulation cell in the eastern equatorial Pacific

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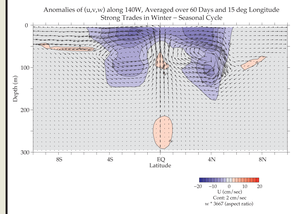
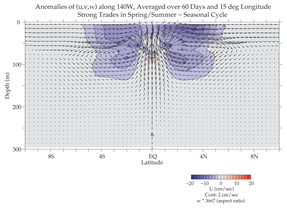
EFFECT OF STRENGTHENING THE TRADES ON MEAN CIRCULATION ALONG 140W

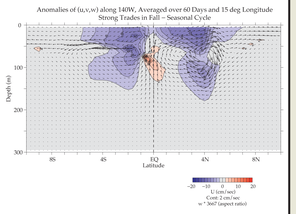
Moderate TIWs



Low TIW Activity



TIW Growth

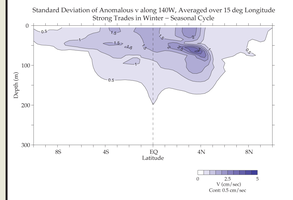


The anomalous zonal circulation that results from strengthening the Trades is characterized by increased westward flow in the South Equatorial Current (SEC), enhanced meridional shear between the SEC and the North Equatorial Countercurrent (NECC), and enhanced vertical shear between the SEC and Equatorial Undercurrent (EUC). The anomalous meridional-vertical circulation is similar to the mean pattern described in the introduction with near-surface poleward Ekman divergence, upwelling along the equator, and downwelling near 4S and 4N. The equatorial symmetry of the meridional-vertical pattern is reduced when TIWs are active due to averaging of a non-integer number of TIWs.

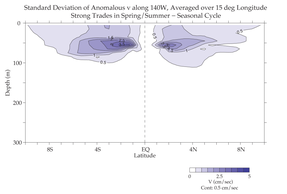
Weakening the Trades produced a nearly opposite mean circulation along 140W; however, significant departures from linearity exist as the average sum of the two anomalies are non-zero and equatorially asymmetric (upper right panel).

EFFECT OF STRENGTHENING THE TRADES ON SCALES OF VARIABILITY ALONG 140W

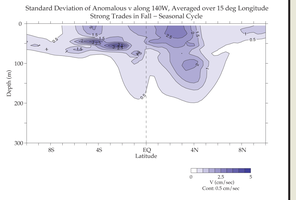
Moderate TIWs



Low TIW Activity



TIW Growth



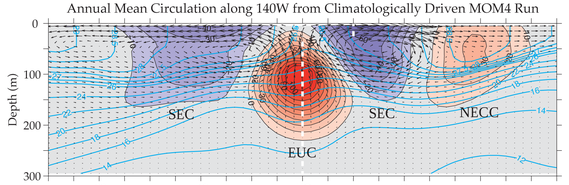
Regions of large variability in the anomalous meridional velocity are nearly equatorially symmetric and confined to the upper 100 m of the water column when the TIW activity is low. During periods when TIWs are active, the areas of high variability become equatorially asymmetric with larger amplitudes and meridional and vertical length scales north of the equator. Anomalously strong Trades were found to increase the TIW amplitudes and modified the phase of the waves consistent with the increased mean shear between the SEC-EUC and SEC-NECC.

Weakening the Trades produced similar patterns of meridional velocity variability; however, the TIW amplitudes were reduced consistent with decreased mean shear in the zonal currents and the variability associated with the sum of the two anomalies is large (lower right panel).

INTRODUCTION

The mean tropical circulation cell in the eastern equatorial Pacific is characterized by strong upwelling near the equator, near-surface poleward divergence, and downwelling near 3-4 degrees latitude associated with the northern and southern cold tongue sea surface temperature fronts. Although multi-decadal horizontal velocity measurements are available on the equator at select Tropical Ocean Atmosphere (TAO) moorings between 165 E and 110W [1], long-term measurements of the tropical circulation cell do not exist. In lieu of cross-equatorial horizontal velocity and divergence measurements, models can be used to study the meridional and vertical structure of the tropical circulation cell and how that circulation is perturbed by varying winds, tropical instability waves (TIWs), and remotely forced waves.

Annual Mean Circulation along 140W from Climatologically Driven MOM4 Run



Colors show zonal current in cm/sec.
Scaled vectors show (v,w).
Select temperature contours are overlaid in cyan.
Dashed white lines indicate TAO and test moorings.

−100 −50 0 50 100
U (cm/sec)
Cont: 10 cm/sec
w * 2200 (aspect ratio)

NUMERICAL EXPERIMENTS

The Modular Ocean Model (MOM4 [2]) driven by climatological forcing is used to study the spin-up of the tropical circulation cell in response to localized strengthening and weakening of the Trade Winds. Climatological heat forcing obtained from monthly ISCCP radiative and OAFlux turbulent heat flux [3,4] and climatological wind stress fields were generated from a high-resolution monthly QuikSCAT climatology [5].

Sixty-day zonal wind anomalies (±0.025 N/m^2) were applied between 148 W and 132 W and 20 S and 20 N during various phases of the cold tongue seasonal cycle and different stages of the TIW evolution. Experiments are identified to by Boreal Winter, Spring/Summer, and Fall.

Winter	Moderate TIWs (JFM)
Spring/Summer	Low TIW activity (MJJ)
Fall	TIW growth (SON)

Results from strong Trade Wind anomaly experiments are shown in the left panels and results from weak Trade Wind anomaly experiments and deviations from linearity are shown in the right panels.

REFERENCES

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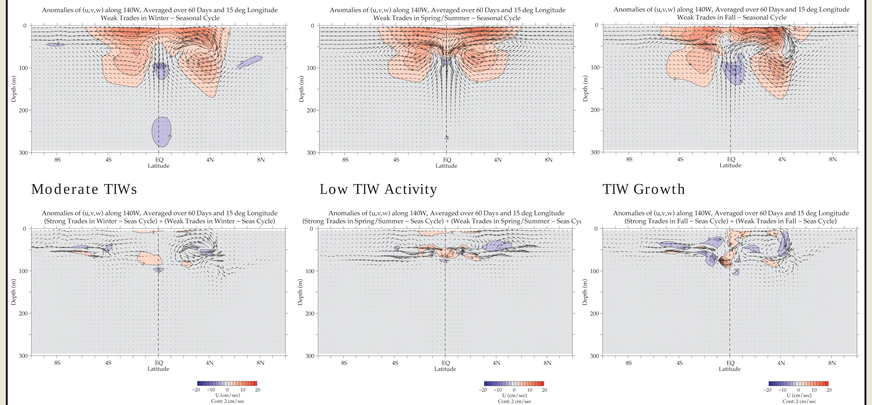
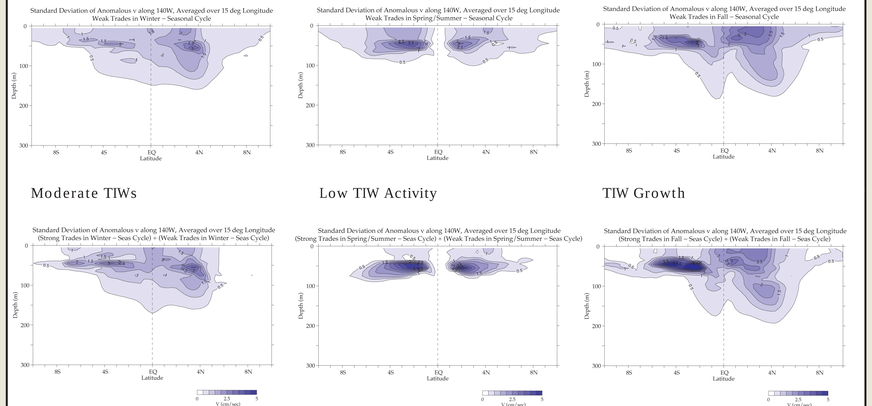
[3] Zhang, Y.-C., W. B. Rossow, A. A. Lacis, V. Oinas, and M. I. Mishchenko, 2004: Calculation of radiative fluxes from the surface to top of atmosphere based on ISCCP and other global data sets: Refinements of the radiative transfer model and the input data. J. Geophys. Res., 109, D19105.
[4] Yu, L., and R. A. Weller, 2006: Objectively analyzed air-sea heat fluxes for the global oceans. To be submitted.
[5] Risien, C. M., and D. B. Chelton, 2006: Global wind stress and wind stress derivative fields from 7 years of QuikSCAT scatterometer data, in preparation.

EFFECT OF WEAKENING THE TRADES ON MEAN CIRCULATION, NONLINEAR RESPONSE



EFFECT OF WEAKENING THE TRADES ON SCALES OF VARIABILITY, NONLINEAR RESPONSE



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